

## APPENDIX C

Felder et al, *Elementary Principles of Chemical Processes* (Wiley 1978), p. 82

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# ELEMENTARY PRINCIPLES OF CHEMICAL PROCESSES

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- (a) *Batch process.* The feed is charged into the system at the beginning of the process, and the products are removed all at once some time later. No mass crosses the system boundaries between the time the feed is charged and the time the product is removed.

*Example.* Rapidly add reactants to a tank, and remove the products and unconsumed reactants some time later when the system has come to equilibrium.

- (b) *Continuous process.* The inputs and outputs flow continuously throughout the duration of the process.

*Example.* Pump a mixture of liquids into a distillation column at a constant rate, and steadily withdraw vapor and liquid streams from the top and bottom of the column.

- (c) *Semibatch process.* The inputs are nearly instantaneous and the outputs are continuous, or vice versa.

*Examples.* Allow the contents of a pressurized gas container to escape to the atmosphere; slowly blend several liquids in a tank from which nothing is being withdrawn.

If the values of all the variables in a process (i.e., all temperatures, pressures, volumes, flow rates, etc.) do not change with time, except possibly for minor fluctuations about constant mean values, the process is said to be operating at *steady state*. If any of the process variables changes with time, *transient* or *unsteady-state* operation is said to exist. By their nature, batch and semibatch processes are unsteady-state operations (why?), whereas continuous processes may be either steady state or transient.

Batch processing is commonly used when relatively small quantities of a product are to be produced on any single occasion, while continuous processing is better suited to large production rates. Continuous processes are usually run as close to steady state as possible; unsteady-state (transient) conditions exist during the start-up of a process and following changes—intentional or otherwise—in process operating conditions.

### TEST YOURSELF

Classify the following processes as batch, continuous, or semibatch, and transient or steady state.

1. A balloon is filled with air at a steady rate of 2 grams per minute.
2. A bottle of milk is taken from the refrigerator and left on the kitchen table.
3. Water in an open flask boils.
4. Carbon monoxide and steam are fed into a tubular reactor at a steady rate, and react to form carbon dioxide and hydrogen. Products and unused reactants are withdrawn at the other end. The reactor contains air when the process is

started up. The  
and flow rate  
Classify the pr

## 5.2. BALANCE

### 5.2a. The General Balance

Suppose methane  
continuous process  
performing as de  
measured and fou

There are only  
the measured flow

1. Methane is leak
2. Methane is eith
3. Methane is accu
4. The measureme

If the measurement  
generation or cons  
unit—are all that c  
rates.

A *balance* (or i  
collection of units,  
way:

*Input* + *generat*  
(enters (produ  
through within  
system system)  
boundaries)

This *general balance*  
any process system: